

T H E
R E P O R T
O F

J O H N S M E A T O N Engineer, and F. R. S.

C O N C E R N I N G

The Practicability and Expence of joining the Rivers FORTH
and CLYDE by a NAVIGABLE CANAL, and thereby to
join the East Sea and the West.

With a MAP of the Country and a PLAN of the CANAL

A D D R E S S E D

To the H O N O U R A B L E

T H E

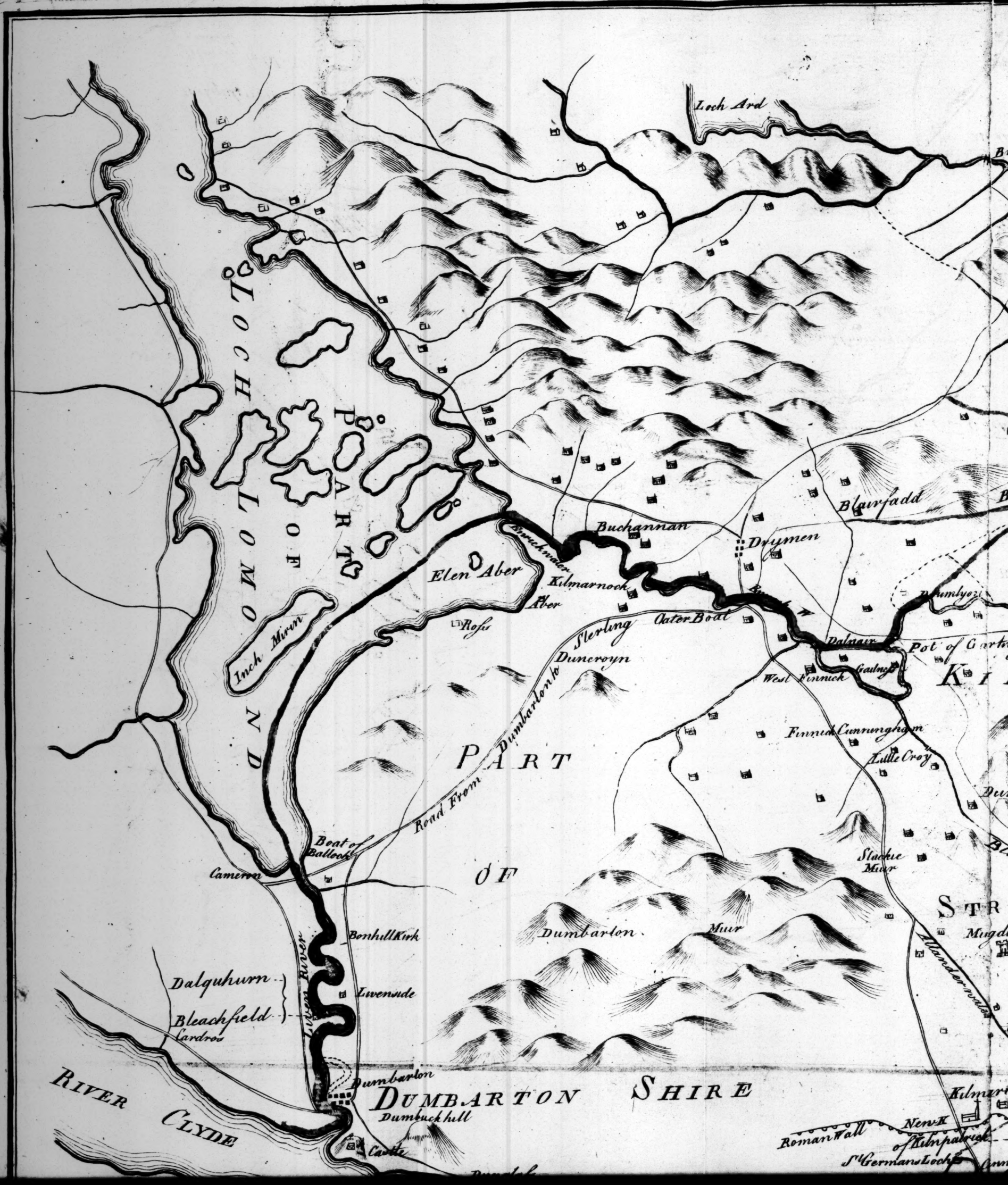
TRUSTEES for FISHERIES, MANUFACTURES, and
IMPROVEMENTS in SCOTLAND; at whose Desire the
S U R V E Y was made.

E D I N B U R G H:

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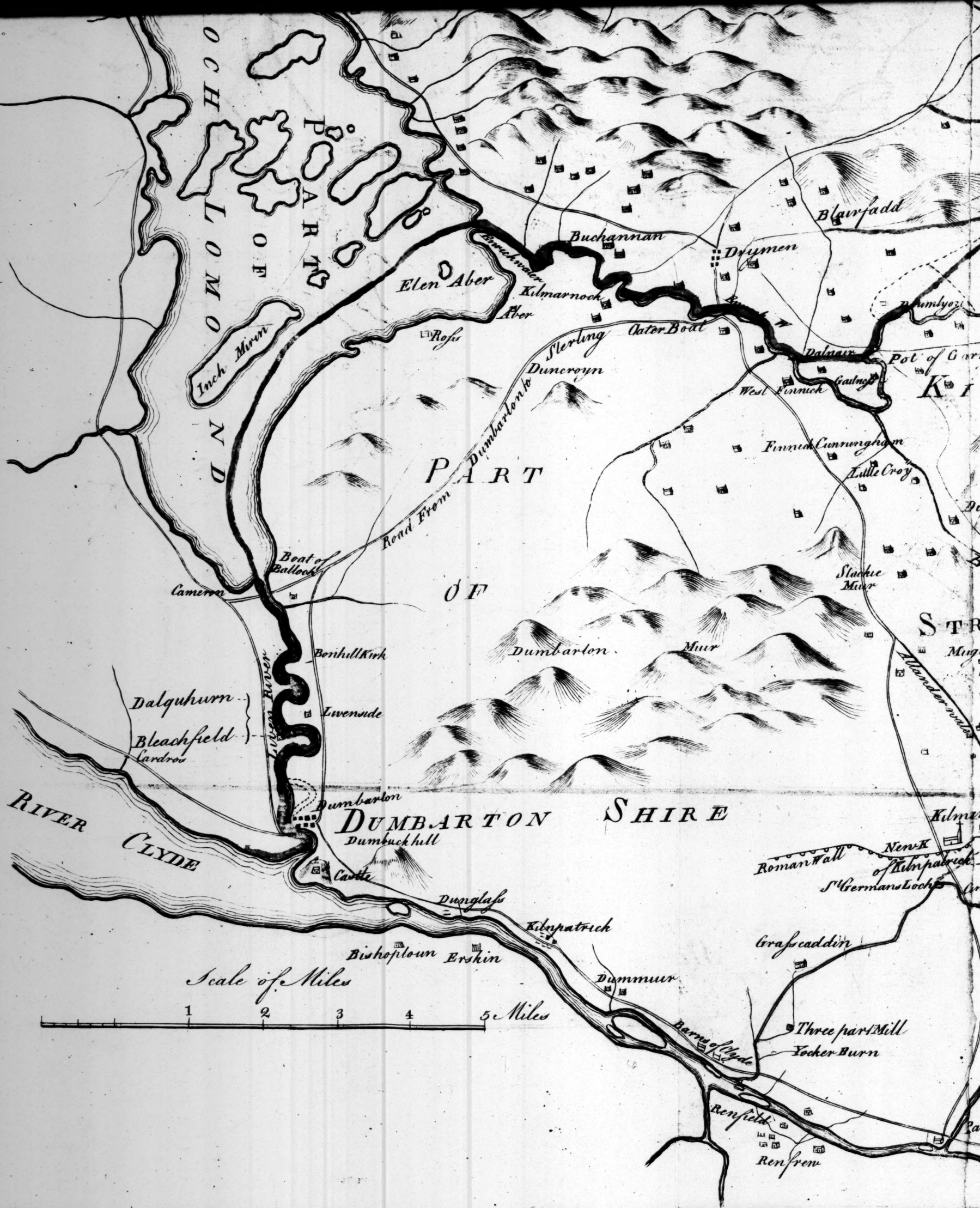
For JOHN BALFOUR Bookfeller,

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TO THE HONOURABLE
THE
TRUSTEES for FISHERIES, MANUFACTURES, and
IMPROVEMENTS in SCOTLAND,
THE
R E P O R T
O F

JOHN SMEATON Engineer, and *F. R. S.* concerning the Practicability and Expence of joining the Rivers FORTH and CLYDE by a navigable Canal, and thereby to join the East Sea and the West.

THE great utility of a navigable communication between the east sea and the west, has given occasion to the forming of several projects for this purpose in different parts of the kingdom of Great Britain; the principal of which are, the *Thames* and *Severn*; the *Trent* and *Severn*; the *Trent* and *Weaver*; the *Calder* and *Mersey*; and the FORTH and CLYDE: But from what I have seen and heard of these matters, I am well convinced, that by far the most easy to be accomplished, not only in point of distance, but in point of perpendicular height, is the last: And it is somewhat remarkable, that, notwithstanding the country at this place lies in general as high, if not higher than any of the rest; yet that through this high ground there happens two different passages, both lower than any of the others, and so much appearance of equality in point of practicability, that, upon ocular surveys,

Several projects for a canal.

Two passages in Scotland.

A

veys, it has remained a doubt which of the two ought to be preferred.

Carron passage.

ONE of these passages is from the *River Carron*, by way of the *Water of Bonnie*, through the *Bog of Dolater*, into the *Kelvin*, and from thence into the *Clyde* by way of the *Yocker Burn*.

Loch Lomond passage.

THE other is by following the *River Forth* some miles above *Stirling*, and then crossing over through the *Bog of Ballat* into the *Water of Enrick*, down to *Loch Lomond*; and from thence by the *River Leven* into the *Clyde* at *Dumbarton*. And as I have, by order of the Honourable the Trustees for fisheries, manufactures, and improvements in Scotland, been at some pains in taking proper observations, in order to determine the preference of these two passages, I shall first endeavour to settle this question, and then proceed more minutely to explain the several leading points that occur in laying out the design for the preferable tract.

General Description of the CARRON Passage.

Carron Shore.

FROM the *Forth*, about three miles up the *River Carron*, to a place called *Carron Shore*, there is at present a good navigation for sea-vessels, drawing from 9 to 10 feet water at spring-tides, and from 7 to 8 at neap-tides; which, from the cuts proposed to be made across the loops, as I am informed, is likely to be improved; and so far I consider the present sea-navigation to extend. From *Carron Shore* to *Tophill*, a little below *Camelon Bridge*, the ground is gently rising, and accommodated as well as possible for a canal: From thence to the point above *Camelon*, between *New-Hall* and *Glenfour*, the ground rises near 60 feet in half a mile, and is more uneven, but yet attended with no considerable difficulty; from thence, the canal may be managed upon the decline of the high ground, so as to run upon a dead level to *Castle-Cary Bridge*, being above 4 English miles: This tract of ground is intersected with haughs and burns, which occur very frequently, and will therefore require a considerable expence in making banks, aqueducts, and

Uneven ground.

and other extra-works ; yet nothing occurs but what may be conquered at a reasonable charge. The principal single work will be an aqueduct-bridge, in crossing *Bonnie Mill Burn* near *Bonnie Bridge*, over which the canal must be carried upon arches. Another, but lesser work of the same kind, will be required in crossing the river *Bonnie* at *Castle-Cary Bridge*. Aqueduct bridges.

FROM hence to the *Bog of Dolater*, which begins a little above *Wineford*, the passage is sufficiently easy by a gentle ascent; and through the said bog (extending almost to *Craigmarline Wood*) there is scarcely 4 feet descent either way in the compass of 2 miles; about the middle of which is the summit between the two seas, and is elevated above high water neap-tides at *Carron Shore* about 147 feet, being distant therefrom about 9 English miles. On each side of *Dolater Bog*, the country rises high, which affords a number of springs and rills, which bring down considerable quantities of water on the least rain; but the principal, which is constant all the year, is the *Burn of Auchinclough*, which discharges itself into the bog, and which, though it now runs into the water of *Bonnie*, might, with very little trouble, be turned so as to run the other way into the *Kelvin*; for a drain that now passes lengthways through the bog, has, for half a mile in the middle thereof, no sensible run at all; so that the same trench is the head both of the *Bonnie* and *Kelvin*. This bog, as it is called, is properly a peat-moss, or morass, and is in general near half a mile broad, but contracted at each end by the high land at E and M, (See the plan of the canal), to about 120 yards; so that it is adapted as well as possible for the formation of reservoirs, canals, and passages for water: Indeed, the whole bog might easily be put under water by a small dam between the high grounds at each of the contracted places. Dolater bog.

FROM the summit, or point of partition, westward, the *Kelvin* runs in an open valley for about 13 miles upon a very regular and almost insensible decline, as far as *Gariscud Bridge*, where it begins to be very rapid, and runs through a very deep channel, quite confined by rocks and precipices, in some places almost perpendicular, down to *Partick*, where it falls into *Clyde*; of this district, all that Valley of the Kelvin.

Allander passage.

Canny Burn passage.

Outfall into Clyde.

can be said, is, that it is not impossible to be made navigable; but it would cost a great sum to make a bad navigation: for this reason, those who have turned their thoughts towards this project have sought out for a new passage into *Clyde*: And nature has kindly furnished two practicable ones; one by the valley of the *Allander*, leaving *Douglastoun*, *Kilmardony*, and *New Kirkpatrick*, all on the right; and cutting through a rising ground between the two last places at T, we are conducted into a valley leading down to *Grafcaddon*. The other passage leads out of the *Kelvin's* valley just above *Gariscud Bridge*, and going by way of *Canny's Burn*, traverses a rising ground at R, and falls into *St German's Loch*, and from thence, by the same valley as the former, to *Grafcaddon*. Neither of these passages are without difficulty, on account of the rising ground to be cut through, being above 30 feet perpendicular above the general level; yet both greatly preferable to the passage by the *Kelvin* below *Gariscud Bridge*; which, besides the incumbrances already mentioned, is filled with mills of various kinds, which occupy the ground where any cuts could easily be made. At *Grafcaddon*, the ground falls considerably in a little space, and then the passage is very easy and regular down to *Yocker Burn*, which discharges itself into *Clyde* almost opposite *Renfield*, and a little above a place called *Barns of Clyde*; from hence downwards, the *Clyde* is navigable at all tides with any vessels that can be expected to navigate upon the intended canal; which I would propose to be such as occasionally can go from *Port Glasgow* or *Greenock* to *Leith*.

FROM the point of partition of the waters in *Dolater Bog*, to *Barns of Clyde*, by the course of the canal, will measure about 18 English miles, (to which measure I all along confine myself); so that the whole length will be about 27 English miles.

General Description of the Passage by way of LOCH LOMOND.

River Leven.

BEGINNING from the *Clyde* at *Dumbarton Castle*, we enter the *River Leven*; which though but $6\frac{1}{4}$ miles long, measuring by the links,

links or turnings thereof, is yet a large river, and brings down a considerable quantity of fresh water at all times of the year; for having the great lake called *Loch Lomond* for a reservoir at its head, which receives the water of several considerable rivers, it always affords a considerable currency in the driest seasons, and is never subject to any great or sudden floods, on account of the great capacity of the aforesaid lake. This river is in a state of nature navigable for flat-bottomed vessels from the *Clyde* to *Loch Lomond* in winter, and wet seasons in summer; but in dry seasons, the navigation is in a manner stopped; for though it affords a good deal of fresh water at all times, yet as it is broad, and runs in a shallow channel, (except about a mile above *Dumbarton*), and has about 20 feet fall from *Loch Lomond* to high water at neap-tides, which are sensible at a place called *Dalquurn Bleachfield*, about a mile and half above *Dumbarton*; consequently there is 20 feet fall in less than 5 miles, which makes the water somewhat rapid, and in dry seasons leaves not above 18 inches depth over the shoals, which are pretty numerous: And though it might not be difficult to improve this navigation, so as better to answer its present purposes; yet it is not capable of any remedy adequate to the purpose of a general navigation, otherways than by locks and dams, to pen up the water from one to another; for as this river cheques in with the high ground first on one side, then on the other, the valley is but ill adapted to a canal the whole length.

FROM the head of *Leven* we traverse about 7 miles of *Loch Lomond*, in which there is no impediment till we come near the mouth of the *River Enrick*, which having its source in an high country, comes down very rapid, and brings great quantities of sand from the mountains, which are lodged near its mouth in the loch, and there, as it were, forms a bar, over which in the summer-state of the loch, there is not above 18 inches water, and serves as a ford in most seasons. To attempt making a passage through this sand by lifting the matter, would be endless: for being situated in a bay which lies open to the west wind, the sand is brought back upon the shore by the action of the wind and waves. I have been since informed,

Loch Lomond.

Sands in the mouth of *Enrick*.

informed, that at the south corner of the bay, at a place called *Aber*, the shore is clear of sand; but being there rocky, to make a passage through the same of sufficient depth *below* the surface of the loch in its *lowest* state, for the passage of loaded vessels, would probably be more expensive than the removal of the bar itself; which I apprehend might be done by running out two jetties about three quarters of a mile into the loch, (for according to my information it is that distance from shore in dry seasons, before we should find navigable water); in which case the current of the river being confined between the jetties, would scour out the sand and keep the passage clear.

Remedy.

River Enrick
below Gart-
nefs.

FROM the mouth of *Enrick*, the river runs in an open valley in a deep channel, and almost upon a dead level, as far up as *Cater Boat*, opposite *Drummond*; which in a right line is about $3\frac{1}{2}$ miles; but by the course of the river, which is very winding, cannot be less than 6. From hence, to the south west corner of *Dalnair Park*, the river measures $2\frac{1}{2}$ miles; the perpendicular rise is almost 11 feet. The valley so far continues open; but as the channel is very winding, and cheques in with the high ground on both sides several times, the best way of making it navigable will be by locks and dams as the *Leven*.

Pot of Gart-
nefs

to be avoided

An hill to be
pierced.

A LITTLE above this, that is, a little above where the *Water of Blain* falls into *Enrick*, the valley is quite contracted, and the river falls over a set of rocks, forming a remarkable cataract, called the *Pot of Gartnefs*; to pass which in the channel of the river would be very difficult. But this may be avoided by cutting a-cross the neck of land, from the south west corner of *Dalnair Park*, into the river above *Gartnefs Mill*; the length will be about $\frac{1}{4}$ of a mile, and the perpendicular rise near 37 feet. In this passage we meet an hill, whose summit rises upwards of 40 feet higher than the level of the river at the head of the aforesaid cataract. But as the length of the hill is not great, it may be pierced with equal ease and by the same means as those mentioned in crossing from the *Kelvin* to *Grascaddon*, in the other passage. This passage by way of *Enrick* in the general map is coloured *Red*.

River Enrick
above Gart-
nefs.

HAVING regained the *River Enrick* above *Gartnefs*, there seems no way but to follow the course thereof $1\frac{3}{4}$ mile, in which space there

there is a rise of 25 feet. This passage is sufficiently rugged, and the valley confined by steep braes and rocks; nor do I see any adequate means of avoiding it, as the country hereabouts is very steep and uneven; however, it may be managed by locks and dams upon the same principle as those below. From hence it is proposed to pass by canal to the *Bog of Bollat*, the summit of which is distant a little above 1 mile, and is elevated above the aforesaid point in the river 129 feet, viz. from the river's surface to the top of the brae 35 feet, and from thence to the summit of the bog 94 feet; so that the summit of the *Bog of Bollat* is elevated above the surface of *Loch Lomond* 202 feet, and above high water neap-tides in the *Clyde* 222 feet, the whole distance being 25 miles.

Canal to Bollat.

THE *Bog of Bollat* is about half a mile long, and about one eighth of a mile in breadth: from the middle or summit, the ground falls away pretty quick both ways, and the valley widens; there are no constant running waters discharge themselves herein, except one small rill that comes in on the north side. There is however a burn called the *Auld Hurr*, which falls into the decline of the valley towards the *Forth*, which might easily be conducted to the summit; but this, at the time I saw it, after a remarkable rainy season, was far short of supplying a navigation. There is also another burn to the west of *Bollat* of much about the same validity, which falls into *Enrick*; the upper part of which might be intercepted and carried to the summit; but still there would remain a great deficiency. I should not however despair, did the point of difficulty rest here, of bringing a sufficiency of water to the *Bog of Bollat*, and of making proper reservoirs there; for it appears, from the face of the country, practicable to lift the *Water of Enrick* 4 or 5 miles above, so as to bring any quantity required to the point of partition; or even to bring a part of the *Keltie Water*, upon a sufficient elevation round the hills, to the same place.

Bog of Bollat.

FROM the point of partition in the *Bog of Bollat*, a valley gradually forms itself to the north, into which the water from the neighbouring hills collect themselves and form a burn; which passing by *Achintroig*, and a place called *Offrings*, falls into the *River Forth*.

Traff from Bollat to the Forth.

Forth, a little below the mouth of the *Keltie*. From the summit of *Bollat* to the *River Forth* is above 4 miles, the last mile of which being through the valley of the *Forth*, has but little descent; so that the greatest part of the whole descent is in the three former miles.

The river
Forth above
Stirling.

FROM the mouth of *Keltie* to *Stirling*, the *River Forth* runs in a remarkably winding and deep channel, and with a slow current, which is however interrupted at three principal places, viz. at the ford of *Cardros*, where there is a fall of about 2 feet; at the ford of *Frew*, where there is the like fall; and at *Craigforth Mill*, about $1\frac{1}{2}$ mile above *Stirling*, where there is a fall of 4 feet. The falls at *Cardros* and *Frew* are occasioned by gravel shoals formed there in the river, and brought down from the hills by the burns that fall into the *Forth* near those places; but that at *Craigforth Mill* is occasioned by a natural rock, which runs a-cross the river, the defects of which as a dam is made good by art, in order to produce a sufficient pen of the water to work the mill and catch salmon. The spring-tides come up to *Craigforth Mill*, and the river is then navigable for lighters or barges to this place, and, according to my information, at neap-tides within half a mile below this place.

Tides to
Craigforth
Mill.

Navigation
above Craig-
forth

easily joined
to that be-
low.

ABOVE *Craigforth Mill*, a navigation is at present carried on upon the *Forth* in small boats as high up as *Gartmore*, except in very dry seasons; these boats bring down lime-stone from the rocks near that place, as I was told. Two locks and one dam would make an open navigation from *Gartmore* to the *Firth of Forth*, at all seasons of the year; and was there any trade of consequence up this extensive valley, would be worth the while, independent of a navigable communication between the two seas. One lock ought to be placed opposite *Craigforth Mill*, and the other lock and dam at the *Ford of Frew*; this, with a little clearance of the shoal at *Cardros*, would make a navigable passage over the same.

Winding
course of
Forth above
Stirling.

FROM the mouth of the *Keltie* to *Stirling* is about 12 miles in a straight line; but, by the course of the river, appears to be more than 20. It may seem that this might be helped, by cutting thro' some of the most remarkable loops; but the surface of the river lies so much within soil, that these cuts, tho' short, would be required

to

to be so deep, that the advantage gained thereby would be by no means adequate to the expence; nor would the making an entire new canal be so easy a matter as the *seeming* flatness of the valley would indicate; for, being interspersed with mosses and broad flades, where the burns come down, which are numerous, the surface of the moss is elevated several feet above, and the flades depressed as many below the mean surface; so that, with extra-cutting in some places, and extra-banking in others, together with the works necessary in crossing the burns, to get rid of their water in rainy seasons, would make this work very expensive.

FROM Stirling to *Alloa*, there is at present an open navigation, but through so winding a passage as is almost without a parallel, it being accounted four miles by land, and 24 by water; some of these loops I apprehend it would be worth while to cut for the improvement of the navigation.

Winding
course of the
Forth below
Stirling.

ACCORDING to this description, it measures by the course of the rivers, &c. from the summit of the *Bollas* to *Alloa*, at least 48 miles; and from *Dumbarton* to the summit of the bog, 25 miles; so that the whole course from *Dumbarton* to *Alloa*, by the loops of the rivers, will be 73 miles; and it further appears, that, by the most direct passage that can be made, it will be at least 40 miles.

Length of
the whole
passage.

COMPARISON of the two PASSAGES.

FROM what has been already observed, it is manifest that the *Loch Lomond* passage is considerably further about than the *Carron* passage, and that it is at least equally embarrassed with difficulties; the only point therefore in which a competition can be supposed, must be on account of expence. In order to bring this matter into a narrow compass, I will suppose the *Loch Lomond* passage to be done at the least possible expence; in which case the distance, as before mentioned, will be 73 miles. The impediments being supposed equal, the difference of expence will lie in two articles, *viz.* the difference of length of the artificial part of the navigation, and

Competition
consists in ex-
pence.

the difference of lockage. To reduce the difference of expence, arising from the difference of length of the artificial part to the most simple form, I will suppose, in favour of the *Loch Lomond* passage, that the parts of the river to be made navigable by means of dams, &c. to be the same expence as the same length of canal; though, in general, this kind of work turns out more expensive in such embarrassed situations.

	Miles.
Comparison of expence.	
The length of the <i>River Leven</i> in a right line	4
The <i>River Enrick</i> , from <i>Loch Lomond</i> to the S. W. corner of <i>Dalnair Park</i> , in a right line	5
From thence to the point of departure from the <i>Enrick</i>	2
From thence by canal to the summit of the <i>Bog of Bollat</i>	1
Length of the artificial part, from <i>Clyde</i> to the point of partition	12
From the summit of the <i>Bog of Bollat</i> to the nearest part of the <i>River Forth</i> near <i>Offrings</i>	4
The cuts and dam upon the <i>Forth</i> being reckoned at one mile, will be greatly undervalued	1
Total length of the artificial part in the <i>Loch Lomond</i> passage	17
The Carron passage measures	27
Difference of length of artificial navigation in favour of <i>Loch</i> <i>Lomond</i>	10

The

	<i>Feet.</i>
The perpendicular height of the summit of the <i>Bog of Bol-</i> <i>lat</i> , above the neap-tide high-water surface of the <i>Clyde</i> at <i>Dumbarton</i> - - - - -	222
The height of the summit of <i>Dolater Bog</i> above high-water neap-tide at <i>Carron Shore</i> - - - - -	147
Difference of perpendicular height in favour of <i>Car-</i> <i>ron Passage</i> - - - - -	75

But this difference of perpendicular, in point of lockage, will
be double - - - - -

150

	<i>£.</i>
I estimate the cutting at L. 1250 <i>per</i> mile, inclusive of ex- tra-banking, bridges, tunnels, towing paths, and con- tingent works; therefore 10 miles will come to -	12,500
The lockage I estimate at L. 100 <i>per</i> foot, rise or fall; the difference being 150 feet, comes to - - -	15,000

The difference of expence in favour of *Carron* -

2,500

So that the *Loch Lomond* passage will cost L. 2500 more than the
Carron Passage, is further about by almost 40 miles, and will be at-
tended with an additional loss of time in passing, and expence in
keeping between 30 and 40 locks in repairs.

Result.

I PRESUME I have now said enough on this head.

B 2

FURTHER

FURTHER PARTICULARS *relating to the* CARRON PASSAGE.

HAVING already given a general description of the path by which the canal may be conducted from *Carron Shore* to *Barns of Clyde*; it remains that I now enlarge upon some matters relative to this scheme, not yet sufficiently explained.

I. As to the method of supplying the canal with water.

Supply of
water at the
point of par-
tition.

THE *first* and grand principle, is to bring a sufficiency of water to the point of partition, which is here in the middle of *Dolater Bog*, not only to answer the expence of water in filling the locks on the passage of vessels, and of the constant leakage, that will always be more or less, through the gates thereof; but also to make good any waste that may happen by soakage through the banks, and into the ground where the canal is carried above soil, or upon an elevated part of the country; or that may arise from the exhalations from the surface by the sun and winds in dry seasons: And it is very evident that the supplies for all these purposes, must depend upon the water brought to the point of partition, till other supplies can be brought into the canal at a lower level in aid thereof. Now, the space of canal that I look upon will chiefly depend upon the point of partition for its supply, will be from the falling in of *Redburn*, a little above *Castle-Cary Bridge*, east, to *Inch Belly Bridge* upon the *Kelvin*, west, which includes a space of $7\frac{1}{2}$ miles: But, before we can determine the quantity of water necessary to supply this space, we must first determine the kind of vessels proposed to navigate this canal, and the tonnage of goods that may be supposed to be carried thereupon.

Sort of ves-
sels to be
used.

WITH this view, I examined the *gaboats* which ply upon the *Clyde*, and are capable of navigating that *Frith* in all common seasons; and which, I apprehend by the same rule, would navigate the *Frith of Forth*, between the Canal and the *Port of Leith*, if found requisite so to do. I found that a middling gaboat, of 56 feet long

long stem and stern, 17½ wide, and drawing 4 feet water, will carry at least 40 tons; and this I look upon to be the largest size that will be convenient for an artificial navigation. Now, suppose 20 of these boats pass *per* day, at an average, in the driest seasons, that is, ten each way; and supposing them to go full loaded from the *Clyde* to the *Forth*, and half loaded from the *Forth* to the *Clyde*, they will carry 600 tons of goods *per* day, and 4200 tons *per* week, in which I reckon 7 days: For though the boats should not work on Sundays, yet as the water will be amassing, the capacity of carriage, in point of water, will not be diminished; which will also be the case, though they don't go regularly. But casting off the 200 tons for accidents and disappointments, and reckoning upon 4000 tons *per* week, this will amount to 208,000 tons *per* year, exclusive of what may further be done when the supply of water is unlimited. The lock-duty, exclusive of freight, would, I apprehend, very well bear 5 shillings *per* ton; but at 2 s. 6 d. 208,000 tons would amount to L. 26,000 *per annum*; from hence I would infer, that if we could furnish water in dry seasons for 20 boats *per* day, there will be water enough, at the lowest tonnage that can be supposed, to raise a much greater annual sum than can be wanted for repairs, and to discharge the interest of the capital to be expended thereon, and, in all probability, more water than the trade can possibly want: But I would not have it inferred from hence, that because the canal can carry 208,000 tons *per* year, that there will be 208,000 tons *per* year to carry; consequently, the price of tonnage must be fixed upon the probability of carriage, which I leave to the decision of those who are better skilled, both in the general trade of this kingdom, and the particular trade of those parts, than I am.

Now it is certain, that every vessel in its passage cannot require more than 2 locks full of water out of the canal of partition; one at its entry into the same, the other at its departure; which locks full of water will either furnish the same vessel, or some other, with passage through all the rest, supposing them of no greater perpendicular rise: I say, cannot require more; because if 2 vessels meet at

Tonnage of
goods that
may be car-
ried.

Amount of
tolls.

Quantity of
water re-
quired to
the boats.

Leakage.

Soakage.

Exhalations.

Quantity of
water how
furnished.Achincloagh
Burn.

a lock, one going down, the other up, they may both pass with one lockful: But supposing the worst, that is, every vessel to take 2 lockfuls from the canal of partition, the size of the vessels being as before mentioned, will require the locks to be 64 feet long and 18 wide; and supposing the rise at each lock to be 3 feet from the canal of partition to *Redburn* one way, and to *Inch Belly Bridge* the other, the water necessary for the passage of a vessel will be 3456 cube feet at each lock at the extremities of the canal of partition, at F and L, and at both, 6912, and for 20 boats 138,240 cube feet *per* day. A well made lock will not leak above its own capacity in 24 hours; but as things cannot always be equally in order, we will allow 2 locks full *per* day leakage; and as the locks may be misused, or accidents may happen by the carelessness common to water-men, we will allow 2 more on this account, in the whole 4 locks full, amounting to 13,824 cube feet, which added to the lockage 138,240 cube feet, makes 152,064 cube feet of water to be expended in 24 hours. Now, within the limits before mentioned, this will be the whole; for in regard to soakage, as the canal will be carried in the sink of the valley, and dug out of the solid, it will not be above the common drainage of the country, and therefore will be more likely to acquire water by cutting of springs than to lose by soakage. In regard to exhalations, I have observed, that ponds, canals, or other stagnant waters of a competent depth, that had no springs, but yet were water-tight, in the greatest extreme of the late dry summers, never lost above 10 inches before they were replenished by casual rains. Now, I propose, that every part of the canal shall be dug one foot deeper than the draft of water of the boats, which will not only give sufficient freedom to their motion, but also by this means the canal will contain within itself a reservoir or magazine for supplying the exhalation.

THE next point is to inquire how this quantity of 152,064 cube feet of water is, in dry seasons, to be collected and brought to the summit of *Dolater Bog* every 24 hours. And the first thing that presents itself is the *Burn of Achincloagh*, which discharges itself in-

to

to the bog, as already mentioned. This burn, according to information received from the miller at *Achinclough*, is capable of furnishing water in the driest seasons, sufficient to work his mill $4\frac{1}{2}$ hours *per diem*. Now, from the quantity I found necessary to work the mill, this will amount to 89,343 cube feet *per diem*. The Burn of *Kilfyth*, by the same kind of examination at *Kilfyth Mill*, I find will deliver 87,003 cube feet in the same time; the sum is 176,346 cube feet that these 2 burns will furnish in 24 hours in the driest seasons; that is, more by 24,281 cube feet than as before required; which affords a surplussage of 7 lockfuls *per diem* to answer contingencies, besides some other supplies that shall be mentioned.

Kilfyth
Burn.

THE burn of *Kilfyth* falls into the *Kelvin* a little below *Achinvole*, at a place about 20 feet below the summit of the bog; but as this burn comes down from high ground, it can be intercepted and carried to the point of partition. The most easy and convenient way of doing this will be to take it up at the tail of *Kilfyth Mill*, and carrying it eastward upon the declining ground, will cross the ridge of hills to the north eastward of a place called *Craigstones*, and fall into *Shien Burn*, with which it can easily be carried to the place of destination.

How carried
to canal of
partition.

IT appears to me, from an observation not very minute, that there is a sufficiency of elevation to carry *Kilfyth Burn* over into *Shien Burn* from the tail of the mill; but should there, on a more accurate level, prove scarcely enough, yet the purposes hereby intended would not be defeated, as there is a fall of between 30 and 40 feet just above the mill; so that by raising the mill-wheel, an additional fall of 20 feet might be gained from the tail thereof, without detriment to the mill.

Additional
fall may be
got, if requir-
ed.

SHIEN BURN is said to afford some water in the driest seasons, and in common seasons a considerable quantity. At the east end of the bog at *Wineford*, a coal-pit drain discharges itself, which affords a constant supply of water, amounting to some lockfuls *per day*; I have not however brought those supplies to account, because it appears, from the preceeding calculations, that the two burns of *Achinclough* and *Kilfyth* are of themselves sufficient. I

Additional
supplies.

have

Redburn.

have taken notice of these others, therefore, as a means of supplying deficiencies, if any such should happen to arise from unforeseen causes. Nor are those the only ones that can be so applied; because, if it should prove necessary, *Redburn*, which together with *Achinclough* forms the *River Bonnie*, a little above *Castle-Cary Bridge*, may easily be brought to the point of partition; for the level of the surface of *Redburn*, at the point of confluence, is not more than 23 feet below the summit of the bog, and distant about a mile; and as *Redburn* is very rapid, it may be lifted so as to run to the point of partition, without going any considerable distance up the burn. This burn I look upon, from inspection, to be at least as good as either *Achinclough* or *Kilsyth Burns*; so that, together with the reservoirs for water, that may be formed, both in the bog and in the hollows of the contiguous hills from whence those burns proceed, it does not admit of a doubt, but that nature has furnished a practicability of bringing as much water to the point of partition as can possibly be wanted; and that by means sufficiently simple and easy.

Further supplies.

I HAVE mentioned, that the space depending upon the waters to be brought to the point of partition, is the space between *Redburn*, east, and *Inchbelly Bridge*, west; for at those places the accession of waters, by taking an occasional supply from *Redburn* into the canal on one hand, and on the other by taking in the *Kelvin* at *Inchbelly Bridge*, will not only countervail any deficiency by leakage or soakage between their junction with the canal to the sea each way respectively, but also to allow of one foot greater height in the locks below those points, to avoid too great a multiplicity thereof. By taking the *Kelvin* into the canal at *Inchbelly Bridge*, the whole collection of little rills and springs that fall into *Kelvin* below the level of *Kilsyth Mill*, (of which there are several constant ones), will be brought to account; and the communication with the *River Loggie* in crossing the same at *Kirkintilloch*, will be an absolute security against any defect in that branch below the same; so that there is all possible certainty, that the canal will be amply supplied from end to end.

Loggie water.

2dly,

II. HAVING now supplied the canal with water, it remains to shew how this is to be done without injury to the mills, and other works, upon the rivers *Carron* and *Kelvin*; which, below the mouth of the *Bonnie* on the *Carron*, and below *Garscud Bridge* on the *Kelvin*, are not only valuable, but are said to be in want of water in dry seasons.

Canal supplied without injury to the mills.

IN order to put this matter into a clear light, let us examine, for how much water we have, by the preceding scheme, taken credit of the aforesaid rivers, and it will appear that we have taken the burns of *Achinclough* and *Kilsyth*, with so much from the others as shall be wanting to make up the deficiencies of the former in supplying the lower parts of the canal with water.

Quantity taken.

	Cube feet.
For supplying the locks of 3 feet rise between <i>Redburn</i> and <i>Inchbelly Bridge</i> , we shall want, as before estimated, per day. - - - - -	138,240
Now, if the locks were proposed to be of 3 feet all the way, the same water would serve them quite through; but being proposed of 4 feet below these points, they will require an addition of one third of the foregoing quantity, which will amount to - - - - -	46,080
The leakage of the locks was before estimated at - - - - -	13,824
Total required - - - - -	198,144
The <i>Achinclough</i> and <i>Kilsyth Burns</i> supply - - - - -	176,346
Deficiency to be taken from <i>Redburn</i> , <i>Kelvin</i> , and <i>Loggie</i> - - - - -	21,798

WHICH deficiency is nearly one eighth of the whole quantity supplied by the 2 burns; that is, as those 2 burns are said to turn their respective mills $4\frac{1}{4}$ and 4 hours, which is together $8\frac{1}{4}$ hours, as much water must be taken from the other rivulets as will turn a common burn-mill with an overshot wheel, a little more than an hour, in order to make good the surplussage above the 2 burns.

Exhalations
and soakage,
no loss to the
mills.

I HAVE not brought the exhalations and soakage through the banks into the above account; for, in regard to exhalations, as the whole canal is proposed to be dug to an extra-depth, in order to take in a surplus quantity of water in time of rains, (at which time the mills have water enough to spare), this may be laid out of the account: And in regard to soakage, though a supply for that purpose will be wanted from the burns, yet as that will return again into the rivers, it is not lost to the mills; and though some part of the soakage may fall into different valleys; yet, as it must be expected, that the rills and springs, that will be intersected by the canal, that used to run into those valleys, will counterbalance the soakage of these parts of the canal, there will be still no water lost to the mills on account of soakage. The quantity then that we are to restore, is the value of 2 burns, one equal to *Achincloagh* and the other to *Kilfyth*, and one eighth part more of each respectively: and this may be done by intercepting and turning some waters that fall into other rivers, into the *Carron* and *Kelvin*.

Enrick
brought in-
to Carron.

FOR this purpose, having examined the country, I find, that a part of the *River Enrick*, near its source, may be intercepted a little above a place called *Randeford*; which, being carried to the west of the ruins of *Sir John the Graham's* castle, and passing by a place called *Bogside*, through a morass that lies nearly upon a level between the two rivers, will fall into *Carron*: The place is marked in the general plan with a yellow line A. The water of *Enrick*, at the point where it is proposed to be turned, appears to be more than double of the burn of *Achincloagh*; but, if unforeseen occasion should happen to require a further supply, it may be procured by turning the upper part of the burn of *Gonakin* into *Carron*, which rises from springs in *Campsie Fells*, and now falls into *Enrick*: This is marked with a yellow line B. With respect to the *Kelvin*, the water of *Glazert* which falls into *Kelvin*, and the water of *Blain* which falls into *Enrick*, have their source near the same place, there being a continued flat valley between them, like the *Kelvin* and *Bonnie*. Near the point of partition of the waters, is a remarkable cascade or cataract, called the *Spout of Ballagin*; which falling from the

Burn of Go-
nakin.

Burn of Bal-
lagin.

the south-side of *Campsie Fells* immediately forms a considerable burn, whose general course is into the water of *Blain*; but is so critically situated, that in time of floods, a part of its waters are sometimes discharged into the *Glazert*, and, with a very little trouble, would be made to do so constantly: This is marked with yellow in the general plan C. This burn appears equal to the burn at *Kilfyth Mill*, and therefore may be substituted in its stead; and the eighth part thereof still wanting, may be made good by intercepting a number of springs, which issue out of the hills on both sides, at a sufficient elevation to be carried over the point of partition into the *Glazert*, which now falls into the water of *Blain*. These springs may be intercepted on the north side, if occasion should require, almost as far as *Dunraith*.

To this method of supply, it may be objected, That, in order to repay the mills on *Carron* and *Kelvin*, I have robbed those on the *Enrick* and *Blain*. But here I must observe, that where there is more work than water, to take a part thereof, though small, is a proportionable loss; but to take away a small quantity of water, where there is much more water than work, is no loss at all.

Objection.

UPON the waters of *Enrick* and *Blain* there are no mills of any consequence. The most considerable are those at the *Pot of Gartness*, which, as I am informed, are far from being fully worked; and, if they were, as a considerable part of the fall there is unemployed, their powers might be greatly increased, though the quantity of water was a little diminished; and it must be remembered, that the whole quantity wanted hence, is only an equivalent to *Achincloagh Burn*, and one eighth more; which burn turns an overshot wheel $4\frac{1}{2}$ hours *per day*: Whereas the river *Enrick*, at the *Pot of Gartness*, is a considerable river, and has a fall there, as was before observed, between thirty and forty feet. However, to cut off all altercation respecting mills, the trustees to be appointed for the execution of this scheme, may safely engage to give the mills on *Carron* and *Kelvin* as much water in dry seasons as they take away, and to make good all damages that may accrue to the others.—I shall now more particularly describe some things, which, though hinted

Mills on En-
rick and
Blain.

at in the general description of the *Carron* passage, have not been fully explained.

Dimensions
of the canal.

III. THE size of the canal I propose to be twenty-four feet in the bottom, and the sides to be sloped at a medium in the proportion of five to three; that is, for every three feet deep, to widen five feet in each side or ten feet on both sides, to be five deep of water, and at a medium seven feet deep within soil; so that its mean width, at the surface of the water, will be forty feet eight inches, and to be made wider in convenient places, at proper distances, for vessels to pass each other.

Height of
locks.

To make the canal less for boats of $17\frac{1}{2}$ feet wide, drawing four feet water, would make them draw hard; and to make it larger, would induce an unnecessary expence. The locks I would propose not to exceed 4 feet rise at each, in order to save water in working them; and, if made with lesser rises, would be too troublesome on account of their number; only between *Redburn* and *Inchbelly Bridge*, as water may there be more scarce, have proposed them of 3 feet rise each.

Hollows how
crossed.

THE several hollows that the canal will intersect in its passage from *Camelon* to *Castle-Cary Bridge*, I have proposed to pass by banking a-cross, so as to raise the water in the same up to the level of the canal. The deepest of which is the first to the west of *Camelon*, marked D in the plan of the canal, which is about 18 feet deep in the deepest part, and 70 yards wide at the top; the others are less considerable, except at *Bonnie Mill*, which I have proposed to cross on arches: This will be about 30 feet deep, and 70 yards wide at top; but the arches need not to extend above 30 yards; the rest may be done by wharfing and banking. The aqueduct-bridge that will be wanted in crossing the *River Bonnie*, just below *Castle-Cary Bridge*, will be necessary, not on account of the depth of the valley, but to give the river a free passage under the canal; 4 small arches, of 10 feet each, will here be sufficient. But, if it is thought more eligible in the execution, the crossing this river may be effected, by forming a dam or wier a-cross the *River Bonnie*. From hence to *Dolater Bog*, there is no difficulty.

Aqueduct-
bridges.

THE

THE canal of partition, extending about $1\frac{1}{2}$ mile between the two locks, at its extremes, marked F and L, in the plan, I would propose to be dug 50 feet wide at bottom, with slopes as before, which will form a reservoir for water, capable of holding three days supply upon a foot in depth. This is as much as can be wanted, especially at first, till the canal has got a large trade upon it. And if any thing further should appear necessary, especially after *Redburn* is brought to the point of partition, I would advise it to be done by banking in a part of the bog, according to the dotted lines G and H, which, by this means, will be formed sufficiently high to yield its contents into the canal of partition by a sluice, as occasion may require. Between these lines is included a surface of 20 Scots acres, which, at 4 feet deep, will contain a supply of 25 days.

Dimensions
of the canal
of partition.

FROM hence to *Inchbelly Bridge*, there is no difficulty. Below this bridge I propose to put a dam at N, in order to force the water at a proper elevation into the canal N O, which is intended to drop into the loggie above the mill-dam at O; which dam will again force the water into the canal O P; and which, by proper locks, conducts us into the river at *Calder Bridge*. A little below this bridge, in like manner, I propose a dam or wier P, to throw a proper body of water into the canal P Q, by which we are conducted to the *Allander*, where the two passages divide, by either of which we may pass upon the same level, into the valley leading down to *Grascaddon*; one up the *Allander*, the other by *Canny's Burn* into *St German's Loch*; a little below which, both passages would unite in the same point at V: It remains, therefore, to give a reason, why, of those two passages, I prefer the latter.

Works in
Kelvin's valley.

Allander.

Two passages.

FOR this purpose, having taken a level from the surface of the water of the *Kelvin* just below *Calder Bridge*, to the summit of each high ground, I found them to differ but inconsiderably in their perpendicular height; the summit of the high ground by the *Allander* passage being 32, and that by *Canny's Burn* passage, being 33 feet above the said water: I likewise, on examination, found that the base of the hill in the *Allander* passage is a mile and half, or 12 furlongs, that would require an extra-depth of cut; six furlongs of which

Observations
on the two
passages.

Canny's Burn
preferred.

which would be above 15 feet deep; whereas, in the *Canny's Burn* passage, the whole length that would require extra-cutting, is not above $2\frac{1}{2}$ furlongs; and there is not quite one furlong that would be above 15 feet deep. If nature had furnished no other passage than that of the *Allander*, something might be done towards alleviating the expence by retrograde locks. But, as this would cause an hindrance of time, as well as an additional cost in the article of lockage, there appears to me no way by which it can be done, either so well or so cheap, as by the *Canny's Burn* passage.

Method of
piercing and
vaulting the
hill.

WHERE the depth exceeds 15 feet, which will not be above 200 yards, I would propose the passage to be by a vault under ground; and tho' the matter of the hill seems to be a loose gravel, yet I apprehend the means are not difficult by which it is to be perforated. I would begin at an end, and open the ground from the top, the same width I intended it at bottom, that is, 18 feet as the locks, with an allowance for the thickness of the walls, and cutting down the sides perpendicular, would shoar the same with boards, beams, and braces from side to side, of ordinary Scotch fir; these keeping up the matter till the arch is built, the shoars that are above the arch may be taken away, and replaced as the work advances, and the cross-braces that interfere with the walls of the arch may be walled in, and afterwards cut out when the whole is compleated.

Canal from
St German's
Loch to
Clyde.

Grascaddon.

FROM *St German's Loch*, I would carry the canal upon the decline of the hill, upon such a level, as with a little extra-cutting, to pass the high ground that lies on the south of the mill-dam of *Grascaddon*; this I propose, in case it should not be agreeable to the Lord of *Grascaddon*, to carry the navigation through this dam, which is an ornamental piece of water, with planting and walks round it, otherwise this part of the canal will be more easily done by passing through this piece of water. From *Grascaddon* mill-dam there is between 20 and 30 feet fall in a little space; but from thence to the *Clyde*, the ground lies upon a gradual descent, in which there is no difficulty.

Jetty.

ENTERING the *Clyde*, a jetty formed of rubble stone may be necessary to keep clear the tail of the cut.

IV. WITH respect to the number of locks; this depends upon the perpendicular height of the whole, and the perpendicular rise proposed at each lock. The perpendicular rise of the whole I make to be 147 feet from the high-water surface at a neap-tide at *Carron Shore*, to the summit of *Dolater Bog*; but as I would propose to keep the surface of the canal somewhat below the surface of the land there, we will call the perpendicular ascent 145 feet. In this I cannot pretend to be exact; for the violent squalls of wind and rain, that subsisted during the whole time of the survey, made it exceeding difficult and troublesome to manage any instrument for this purpose: It is possible I may have erred some feet in the whole perpendicular; but as from the direction in which the wind blew, I am inclined to believe, that what error there may be, is by exceeding the truth, if it should be found upon re-examination to be 5 feet less than I have made it, (or even double that quantity), it will make no alteration in the general design, nor produce any other effect than the saving so much in the lockage of that perpendicular: and hence it appears, that an exact knowledge of the perpendicular is not at present necessary to determine the practicability of the scheme.

Number of locks.

Difficulty in taking the perpendicular.

Exact knowledge of the perpendicular not necessary till the execution.

IT may likewise be questioned, whether the perpendicular elevation of *Dolater Bog*, is the same above the *Firth of Clyde*, as it is above the *Firth of Forth*; and it is possible it may not. But as water undisturbed, naturally places itself upon a level; and as the disturbing causes, viz. the winds and tides, frequently act in opposite directions, we may be assured that the mean height of the two seas is not so different as to make any material difference in the scheme proposed; accounting therefore the perpendicular height both ways 145 feet, we shall have the number of locks as follows.

Question, if the two seas are upon a level.

From

	N ^o of locks
From <i>Carron Shore</i> to the intended level of the canal above <i>Camelon</i> , I make to be 108 feet; which, at 4 feet each, requires. - - - - -	27
From thence to <i>Castle-Cary Bridge</i> , the canal being upon a level, will require none; but from <i>Castle-Cary Bridge</i> to <i>Redburn</i> , there is a rise of 16 feet; which, at 4 feet each, will take - - - - -	4
From <i>Redburn</i> , into the canal of partition, being 21 feet, at three feet each, will require. - - - - -	7
Number of locks from <i>Carron Shore</i> , to the point of partition. ———	38
From the canal of partition to <i>Inchbelly Bridge</i> , I estimate the fall at 36 feet; this, at 3 feet each, will take - - - - -	12
From thence to the <i>Clyde</i> there will remain 109 feet; which, at 4 feet each, will take - - - - -	27
Number of locks, from the point of partition to the <i>Clyde</i> ———	39
Number of locks in the whole. - - - - -	77

Principles,
by which the
number of
locks may be
contracted.

N. B. The above is the *greatest* number that can be required; for if, in the execution, it should appear, that the supply of water should turn out more liberal, or a less number of vessels expected to navigate than I have supposed; then some expence may be saved by making the rise at the locks greater in general, and without preserving a strict equality; by which means they might be made more readily to suit the ground. It must however be observed, that the highest lock determines the quantity of water to be used; for was there but one lock of 8 feet in the whole collection, this would occasion as great a consumption of water, as if they were all of the same height; unless an extra-supply could be brought to this lock to set against the extra-quantity.

Method for
preserving
private pro-
perty.

V. WHEREVER the canal is by banking held up above soil, that is, above the natural surface of the adjacent land, it is proposed to cut back-drains behind such banks, to receive any leakage that otherways might hurt the adjacent soil, and to conduct the same to some common water-course; also to lay tunnels under the bottom of

of the cut, to communicate such water-courses a-cross the same as require to be preserved, or whose elevations may not suit to be brought into the canal. Also to make bridges in proper places over the canal, for communication between such properties as shall be severed by the same: and to make gates upon the towing paths between every fence, and double gates, if required, for the divisions between different properties, with over-falls in proper places for discharging the surplus water; and whatever else may appear necessary for preserving the possession of each person's property as near as may be in the same state as it shall be before the execution of this project.

VI. IT is very difficult, if not impossible, upon one survey, to take in every view of a subject so complicated; I therefore consider what I have reported, as shewing the general practicability of the proposed scheme, with one method of executing the same; but as it is most probable that many improvements may be made, whenever it is reconsidered for execution, the trustees appointed should be invested with sufficient power for doing whatever then shall appear necessary.

Exact determination difficult in one survey.

ESTIMATE of the EXPENCE of making the CANAL.

The canal being 24 feet mean width in the bottom, and 7 feet mean depth, with slopes, as 5 to 3, the width at top will be 48 feet, and mean width 36 feet, will contain 28 cube yards, in each yard running, and in a mile 49,280 cube yards of digging, which, at 3 pence <i>per</i> yard, comes to L. 616 <i>per</i> mile, and for 27 miles in length to		£ 16,632
To extra-digging in the canal of partition, to make it 50 feet bottom, 53,308 yards, at 3 pence	-	667
To extra-work in making passing places, and some additional measure by turning the angles, allow upon the whole the value of one mile	-	616
D	Carried forward	<u>£ 17,915</u>

Brought forward £ 17,915

The canal being 48 feet at top, allow the same width for the banks on each side, that is, 48 yards in breadth over all, which makes, in one mile, 84,480 square yards, which is $15\frac{1}{2}$ Scotch acres nearly; and for 27 miles, $418\frac{1}{2}$ acres; which, supposing them to be purchased at a medium at L. 20 an acre, comes to - - - 8,370

N. B. The greatest part of the tract is corn-ground; but as there is a considerable quantity of pasture and moor-grounds of small value, and the banks being possessed by the owners of the respective lands, are generally supposed to be of half value; I suppose the above price at a medium may be sufficient; if otherwise, the extra-value must be added.

Besides what is immediately occupied by the canal and its banks, land will be wanted for conveniencies, trenches, reservoirs, &c. which, in the whole, may amount to 20 acres - - - 400

The number of locks being 77, at L. 400 each, will amount to - - - 30,800

To extra-digging, in passing a narrow gripe between two rising grounds a little to the south-westward of *Mungul's* house, marked A, - - - 100

To extra-digging through the summit of the ground between *Glenfour* and *Newhall* above *Camelon* - - - 100

To extra-banking a-cross 6 haughs or hollows, between that place and *Bonnie Mill*, at an average, L. 100 each - - - 600

To an aqueduct-bridge in passing *Bonnie Mill Burn*, and extra-banking up to the same, with an over-fall for discharging the surplus-water of the canal - - - 1,000

To extra-work in passing *Seabeg's Wood*, *Trannock Burn*, *Acre Burn*, and some other haughs and risings from thence to *Castle-Cary Bridge* - - - 400

Carried forward £ 59,685

	Brought forward	£ 59,685
To an aqueduct-bridge, for passing the <i>River Bonnie</i> , near <i>Castle-Cary Bridge</i> , and extra-banking there	- -	800
To a shuttle for taking in water, as occasion may require from <i>Redburn</i> , and an over-fall for discharging the surplus-water	- - - -	20
To two miles of trenching, in bringing <i>Kilsyth Burn</i> together with <i>Shien Burn</i> , into the canal of partition, which, at one shilling <i>per yard</i> , comes to L. 176; and allowing L. 74 for extra-cutting, with such small tunnels and bridges as may be wanted, under and over the same, together with a shuttle and over-fall for taking in the water and discharging the superfluous water; this work will come to	- - - -	250
To building a dam or wier a-crofs the <i>Kelvin</i> below <i>Inch-belly Bridge</i> , with proper shuttles for drawing off the water occasionally	- - - -	500
To building another such dam below <i>Calder Bridge</i>	- -	500
To an aqueduct-bridge for crossing the <i>River Allander</i> , and extra-banking there	- - - -	300
To extra-work in piercing and vaulting a passage through the high ground, between <i>Canny's Burn</i> and <i>St German's Loch</i>	- - - -	1,200
To extra-work in passing <i>Grascaddon</i>	- - - -	100
To extra-work in making a jetty for defending the mouth of the canal, and clearing the passage into <i>Clyde</i>	- -	150
To five public-road bridges, viz. at the road from <i>Falkirk</i> to <i>Carron</i> , at <i>Camelon</i> , at <i>Castle-Cary</i> , at <i>Canny's Burn</i> , and at <i>Yocker</i> , at L. 100 each	- - - -	500
To 21 bridges, where the lesser roads intersect the canal, at L. 75 each	- - - -	1,575
To 28 private bridges that may be wanted for preserving communications between the lands, making,		

	Brought forward	£ 65,580
with the public-road bridges, at an average, two in a mile, at L. 50 each	- - -	1,400
To 13 large tunnels for communicating the lesser brooks under the canal, at L. 40 each	- - -	520
To 68 small tunnels for preserving water-courses, making, together with the large ones, at an average, three in a mile, at L. 10 each	- - -	680
To making towing paths, back-drains, gates, towing bridges, &c. at L. 20 per mile	- - -	540
To bringing the <i>Water of Enrick</i> from a little above <i>Ran-deford</i> into <i>Carron</i>	- - -	150
To bringing the <i>Burn of Ballagin</i> , with some springs rising out of the hills to the west of the spout of <i>Ballagin</i> , into <i>Kelvin</i>	- - -	100
To temporary damages, to lands and mills, unforeseen accidents, impediments, and works, engines, utensils, and supervisal	- - -	10,000
TOTAL		£. 78,970

A P P E N D I X.

AS the noblest work of the kind, that ever has been executed, viz. the CANAL ROYAL OF LANGUEDOC, has been generally esteemed not to answer the expence, this will undoubtedly be made an argument against the present proposition; I shall therefore oppose some matters of fact relating to the *French* canal by way of parallel.

CANAL of LANGUEDOC. CANAL proposed between the FORTH and CLYDE.

Length of the canal between *Port de cette* on the Mediterranean and *Thoulouse*, is 152 *English* miles; besides a river-navigation from *Thoulouse* to *Bordeaux*, which is above 100 miles more; so that the whole length of inland-navigation, is above 250 *English* miles between the sea-ports.

Suppose the vessels make way at an average $1\frac{1}{2}$ miles per hour, the passage will take 14 days, of 12 hours each.

The perpendicular height of the point of partition is 639 *English* feet, above the two seas.

This canal is navigated by 100 locks of above 8 feet rise each.

The expence of this undertaking has been L. 612,500 Sterling.

This work is still incompleat, by reason of shoals in the *River Garonne*, below *Thoulouse*, which in dry seasons greatly interrupt the vessels; to carry the canal below which, as the only remedy, is estimated to cost L. 43,750.

Length of the canal between *Carron Shore* and *Barns of Clyde*, is 27 *English* miles. Sea-vessels go up to *Carron Shore* and to *Dumbarton*, the distance of which by the canal will be 33 miles; but reckoning from *Port Glasgow* to *Leith*, the distance will not exceed 70 *English* miles.

Suppose the vessels to make way at an average $1\frac{1}{2}$ miles per hour, the passage will be but 4 days, of 12 hours each.

The perpendicular height of the point of partition in the proposed canal, is 145 feet.

This canal is to be navigated by 77 locks, of between 3 and 4 feet rise each.

The expence of this undertaking is estimated at L. 78,970.

This canal drops into the *Rivers Carron* and *Clyde*, in the tide's way, at places where there will be no obstruction to the vessels proposed to navigate the canal, in the driest seasons at high water, to proceed on their voyage to their respective sea-ports.

Now,

Now, if it may be admitted, that as *great* a trade is likely to be carried on between the *Forth* and *Clyde*, where the sea-navigation is long and dangerous, the inland short and easy, as between the *Gulf of Lyons* and the *Bay of Biscay*, where the sea-navigation is open at all times, though long, the inland navigation tedious, and at some times almost impassable for want of water over the shoals in the river, the inference is plain, That the same tolls which will hardly keep the *French* canal in repair, will make this a very beneficial undertaking to the *British* adventurers.

POSTSCRIPT.

P O S T S C R I P T.

ON further considering the matter of the foregoing report, I am of opinion it will be eligible to carry *Redburn* into the canal of partition, not as a subsidiary expedient in case of need, but to be applied in the first construction, the charge whereof will be amply recompensed by the omission of 5 locks between *Redburn* and *Inch-belly Bridge*; for the 3 feet locks proposed in that district may then be of 4 feet, the same as all the rest; and it will appear from what has been said page 24. that the water expended on the whole will be precisely the same: so that then the number of locks will be 36 each way, and in the whole 72.

Austhorpe, 1. March 1764.

J. S M E A T O N.

SINCE the foregoing report, with the preceding article by way of postscript, was delivered to the Honourable Trustees, I have discovered, that notwithstanding the care and pains I took to be correct, I have committed an error, in supposing the *Scotch* chain, with which the measures of the length of the tract for the canal were taken, to consist of 70 feet each; whereas in reality it consists of 74: This difference will not however in any respect affect the general principles upon which the preceding scheme is built, nor the estimate in any articles except where the length of the canal is concerned. This length now appears to be $28\frac{1}{4}$ miles instead of 27, as before supposed; and this addition of $1\frac{1}{4}$ mile will affect the estimate in the whole L. 1322 : 10 : 0. But as by the foregoing article of postscript, there will be a saving of at least L. 1600, the estimate upon the whole will be rather less than greater, in which there is ample allowance for contingencies.

N. B. The true measure of the canal is 2010 *Scotch* chains; which, at 70 feet per chain, comes to 26 miles, 5 furlongs, 7 poles and $4\frac{1}{2}$ feet: This for a round number was called 27 miles; but at 74 feet to the chain, makes almost $28\frac{1}{4}$ *English* miles.

J. S M E A T O N.

E S T I-

ESTIMATE of the EXPENCES attending the maintaining
and preserving the NAVIGATION of the CANAL, and
the collecting of the TOLLS.

For the first YEAR.

To 16 labourers at 1 s. per day each, (or their equivalent in men, whose labour is reckoned at a different rate), their wages per annum will be L. 15 : 12 : 0 each, and for 16	£ 249 12 0	
To two masons and two carpenters at 1 s. 6 d. per day each, (or their equivalent), which comes to L. 23 : 8 : 0 per year each; and for the four	93 12 0	
To two overseers at L. 40 a-year each, to take account of the time, and oversee the work of the above men, supposed to be divided into two gangs	80 0 0	
To a surveyor per annum for directing the re- pairs of the whole	80 0 0	
Sum for workmen's wages per annum	£ 503 4 0	
The tools and materials consumed by the working hands, I suppose will be equivalent to their wages, the two first articles; which together amount to	343 4 0	
Sum of expence for common annual re- pairs		£ 846 8 0
To the clerk for collecting the tolls from the toll-gatherers, and paying the same to the treasurers once a month, and keeping the accounts relative thereto, per annum	£ 80 0 0	
To two toll-gatherers, one at each end of the canal, at L. 40 a-year each	80 0 0	
To one ditto at the point of partition, at	30 0 0	
Carried forward	£ 190 0 0	£ 846 8 0

Brought forward £ 190 0 0 £ 846 8 0

To six men stationed as lock-keepers, on different parts of the canal, to be a check upon the bargemen from doing damage to the works, by running against the lock-gates, leaving the cloughs running, so as to let off the water, &c. at 3 s. 6 d. per week each

54 12 0

To books, paper, &c. per annum

15 0 0

To letters, messengers, and other contingent expences

30 0 0

Sum for clerks, toll-gatherers, lock-keepers, &c.

289 12 0

Total common annual expence

£. 1136 0 0

Suppose to be laid by each year, to answer the above, and for the purposes hereafter mentioned

1600 0 0

Then the annual overplus will be

£ 464 0 0

For the first 20 YEARS.

In 20 years the said L. 464 of annual surplus will amount to

£ 9280 0 0

I suppose, in that period, many of the locks will want new gates, or which will gradually fail in a few years after: I therefore suppose them all made new at the end of 20 years; and therefore 72 locks at L. 60 per lock

£ 4320 0 0

The bridges and other works of timber will likewise want repairs, which, I suppose, upon the whole, to amount to one sixth of the locks

720 0 0

Sum for repairs at the end of 20 years

5040 0 0

Which taken from the above accumulated sum of L. 9280, leaves in hand at the end of the first 20 years

£ 4240 0 0

E

For the second 20 YEARS.

Remaining on hand at the end of the first 20 years as above	-	-	-	-	£ 4240 0 0
The interest thereof for 20 years more at three per Cent.	-	-	-	-	2544 0 0
The accumulation of the before mentioned annual surplus sum of L. 464, will, in the second 20 years, as in the first 20, amount to	-	-	-	-	9280 0 0
Sum in hand at the end of 40 years	-	-	-	-	£ 16,064 0 0
At that period, the second set of lock-gates will want renewing as before; and as the thresholds will want renewing also, I estimate the repairs at L. 70 a lock; this for 72 locks will be	-	-	-	-	£ 5040 0 0
And as the second repair of other work may be in proportion, viz. one-sixth of the locks, this will be	-	-	-	-	840 0 0
Sum of the repairs wanted at the end of 40 years	-	-	-	-	5880 0 0
Which, deducted from the above sum then in hand, there remains in hand at the end of 40 years	-	-	-	-	£ 10,184 0 0

For the third 20 YEARS.

Remaining on hand at the end of 40 years, as above	-	-	-	-	£ 10,184 0 0
The interest thereof at 3 per Cent. for other 20 years	-	-	-	-	6,110 8 0
The accumulation of the before mentioned annual surplus sum of L. 464, will, in the third 20 years, as before, amount to	-	-	-	-	9,280 0 0
Sum in hand at the end of 60 years	-	-	-	-	£ 25,574 8 0

Brought forward £ 25,574 8 0

At that period, I suppose the locks in general may need rebuilding; but as the greatest part of the stone, and some other of the materials may be of service, and the excavation already made, they may be made as good as at first for L. 300 each, at an average; therefore will cost

£ 21,600 0 0

And if we suppose the other works to follow the same proportion as above, they will cost, to make all as good as at first

3,600 0 0

Sum for making all the works as good as at first at the end of 60 years

25,200 0 0

Which deducted from the above sum then in hand, there remains of overplus in hand, at the end of 60 years, after every thing is made as good as at first

£ 374 8 0

N. B. In the preceding estimate, I have endeavoured to shew, what sum of money applied from the beginning will preserve the works to perpetuity. But I apprehend this to be altogether a needless supposition; for, if the work will defray the common expences and repairs for the first 20 years, viz. L. 1136 per annum, there is no doubt to be made, that the increase of trade naturally following the use of these undertakings, will answer the greater repairs that must afterwards follow.

Austhorpe, 22 December
1764.

J. SMEATON.

REFERENCES

C

At the same time, the water level in the Canal of the
may be raised by the same amount as the water level in the

of the Canal, the water level in the Canal of the
may be raised by the same amount as the water level in the

for the same reason, the water level in the Canal of the
may be raised by the same amount as the water level in the

And it is not necessary to raise the water level in the Canal of the
to make it as good as the Canal of the

Thus, by raising the water level in the Canal of the
the water level in the Canal of the

thing is to raise the water level in the Canal of the
to make it as good as the Canal of the

But if the water level in the Canal of the
is raised by the same amount as the water level in the

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REFERENCES to the PLAN of the CANAL.

The course of the Canal is actually surveyed; but the other objects at a distance from the Canal are inserted from the eye.

The compass is set according to the magnetic direction.

The places of the locks cannot be exactly assigned, till the ground is laid out for execution; but are inserted in order to give a general idea of their situation.

At *Carron Shore* the rise of spring-tides is from 8 to 9 feet, and of neap-tides from 6 to 7.

	Feet.	Locks.
B From <i>Carron Shore</i> to B, a gentle rise of about	44	
which will require		11
From B to C, a quick rise about	64	16
From C to <i>Castle-Cary Bridge</i> , a dead level	0	0
From <i>Castle-Cary Bridge</i> to <i>Redburn</i> a rise of	16	4
From <i>Redburn</i> to F, that is, the level of the water in the Canal of Partition, being two feet below the surface of the ground in the summit of <i>Dolater Bog</i>	21	7
Total Rise	145	38

From L, the level of the water in the Canal of partition to *Inchbelly Bridge*, a very gentle descent, by estimation

	Feet.	Locks.
	36	12
From <i>Inchbelly Bridge</i> , a very gentle descent to <i>Calder Bridge</i>	}	}
From <i>Calder Bridge</i> to <i>St German's Loch</i> , the Canal proposed to be carried upon a dead level. The present surface of <i>St German's Loch</i> is about two feet higher than the proposed Canal.		
From <i>St German's Loch</i> to <i>Grafcaddon</i> , a very gentle fall.		
At <i>Grafcaddon</i> , a fall of near 30 feet in a small space.		
From thence to the <i>Clyde</i> , a very gentle fall.		
Total fall	109	27

Total Number of Locks - - 77

A A is a narrow gripe between two rising grounds.

C At C the ground rises to an extra-height of about 7 feet, the base thereof being about 400 yards.

D D is an haugh or hollow 18 feet deep in the middle, and about 70 yards broad at top.

There are five more hollows, but lesser ones, betwixt this and *Bonnie Mill*, all which are proposed to be crossed by banking.

At *Bonnie Mill* there is a deep valley 30 feet deep in the middle, and about 70 yards broad at top, proposed to be crossed by an aqueduct-bridge.

Betwixt *Bonnie Mill* and *Castle-Cary Bridge*, 3 burns to be crossed by large tunnels.

Betwixt *Acre Burn* and *Castle-Cary Bridge*, some uneven ground to be passed by extra-cutting and banking.

At *Castle-Cary Bridge*, the *River Bonnie* to be crossed by an aqueduct-bridge.

E M At E and M, the high lands contract the valley so narrow, that a dam or bank in each place, about 120 yards long and 6 feet high, would, if required for a reservoir, lay the whole space between, that is, the whole of *Dolater Bog*, under water, which comprehends at least 150 acres.

F L F and L shew the places of the two locks at the extremities of the canal of partition, to be served with water by the burns of *Achinclough*, and a trench to bring in the burn of *Kilsyth*, and also *Redburn*, if occasion requires.

G H G and H shew the situation, where if need be, two banks may be formed, which, together with the banks of the canal south, and the high ground north, will inclose a space for a reservoir above the surface of the ground containing 20 acres *Scotch* measure, which, at 4 feet deep, will serve the canal 25 days independent of any other supply; this reservoir may be of any extent required, even to the extent of the whole bog, as already remarked.

I K Between I and K the water at present has no apparent motion.

N At N is proposed a dam to throw the *Kelvin's* water into the canal N O.

At

O At O the navigation is to cross the Loggie through the mill-pond.

P At P a dam proposed to be built to throw the water into the canal leading down the valley.

Q At Q an aqueduct-bridge for crossing the *Allander*.

R At R the ground rises 33 feet above the level of the *Kelvin's* surface at *Calder Bridge* P, which is to be passed by a vault 200 yards in length into *St German's Loch*.

Q S T V Q S T V shews another practicable passage for the canal.

T At T the ground rises 32 feet above the level of the *Kelvin's* surface at *Calder Bridge* P; but as the ground rises from the *Allander* to T, it would require vaulting $\frac{3}{4}$ of a mile.

V V shews the place where the two passages unite.

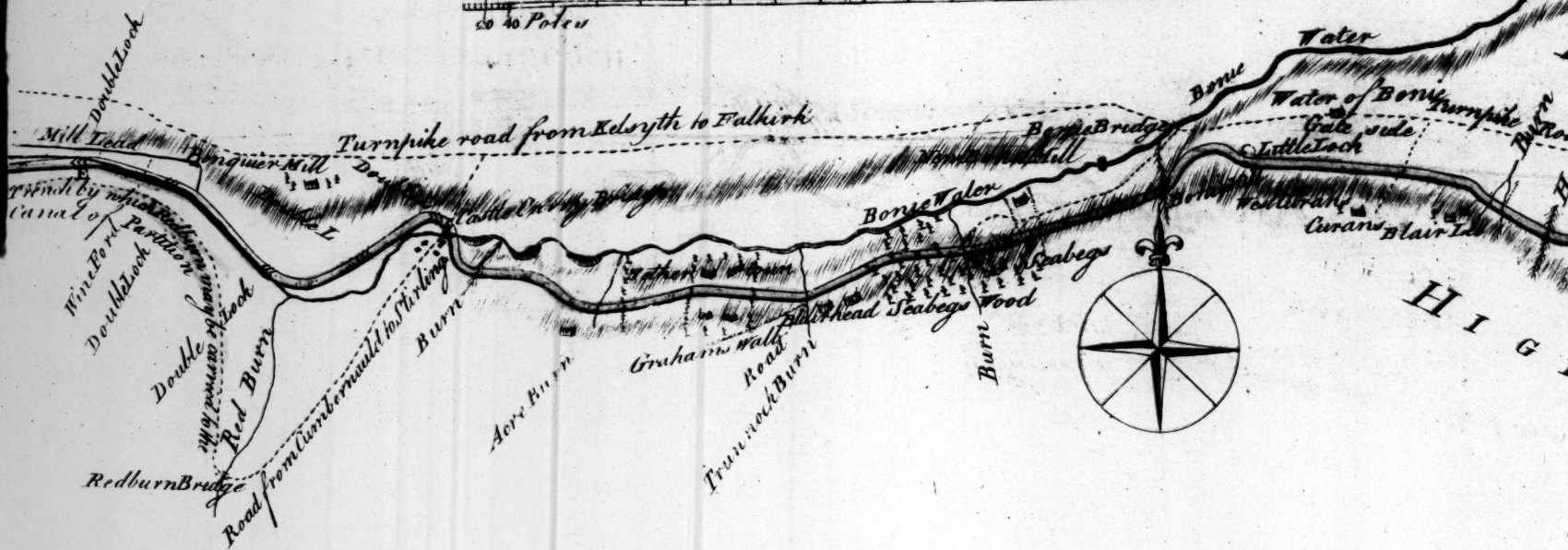
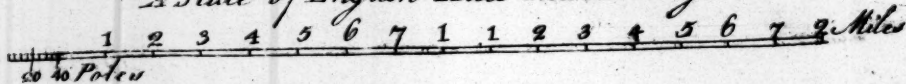
The *Allander* passage being thought preferable, the survey was carried through the same, and from thence through *St German's Loch*, by *Canny's Burn*, to *Gariscud Bridge*; so that the part of the canal now proposed, extending from *Gariscud Bridge* to the *Allander*, is laid down from the eye.

W W is a rising ground to be cut through.

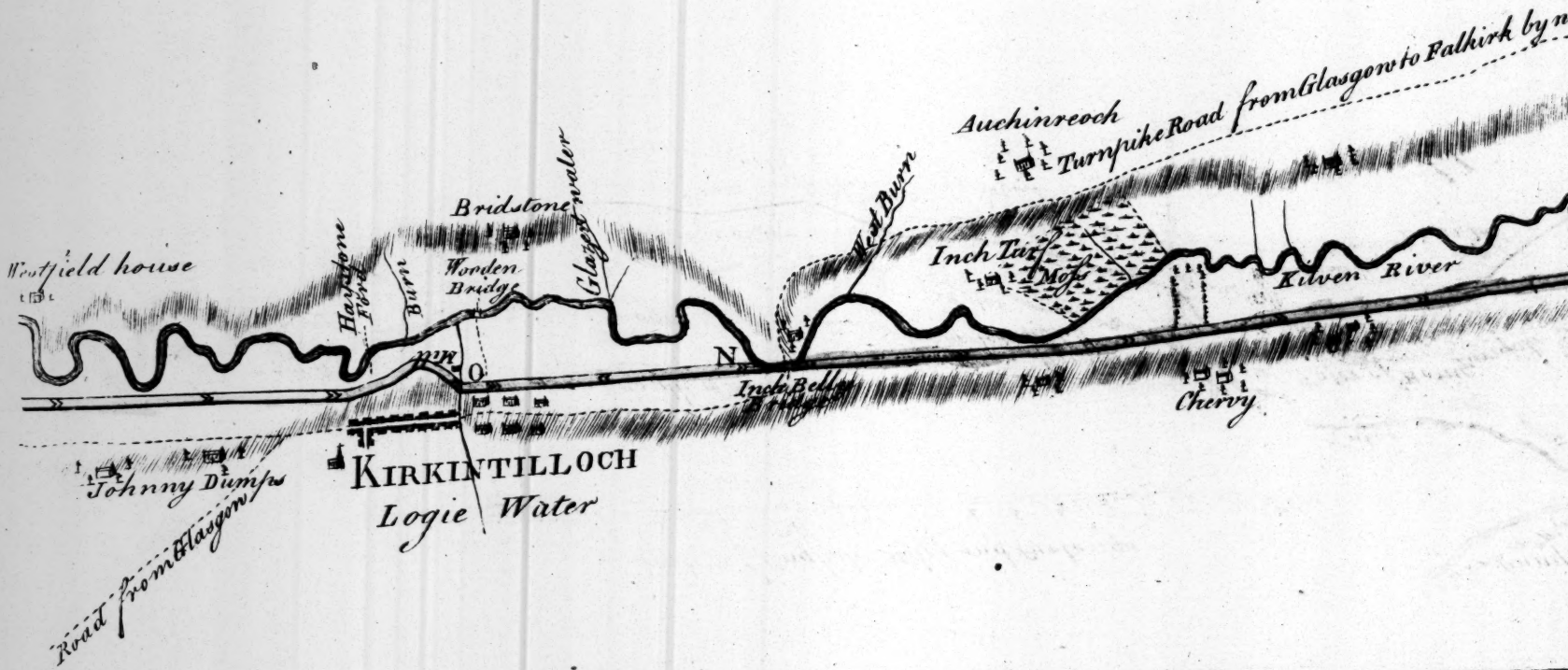
At *Barns of Clyde* the rise of spring-tides is 6 feet, and of neap-tides 4 feet.

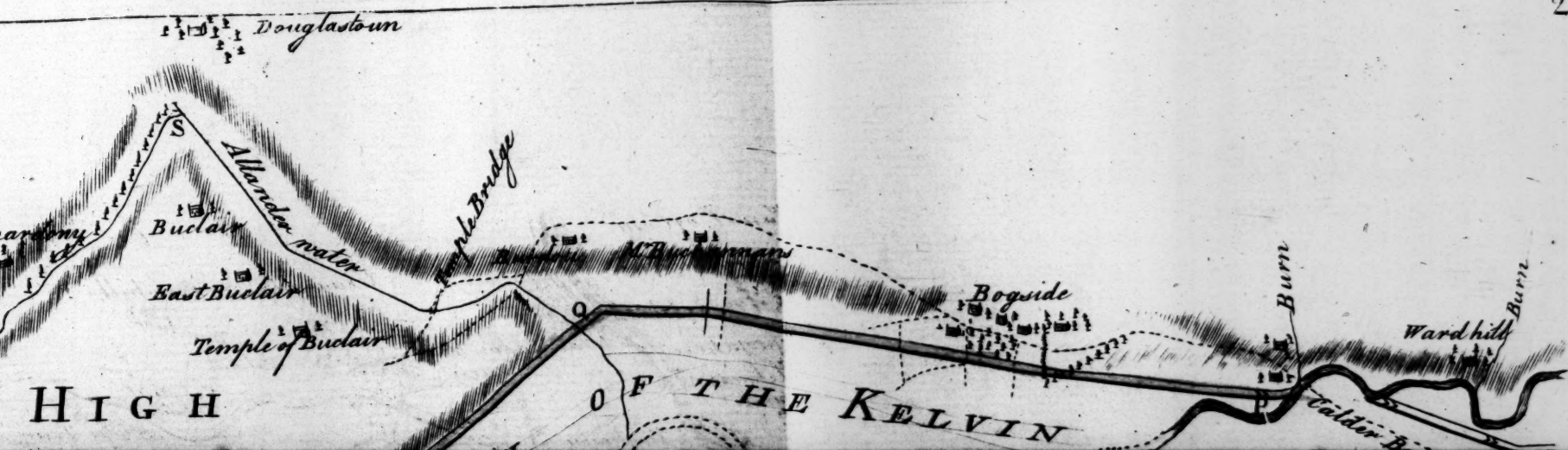
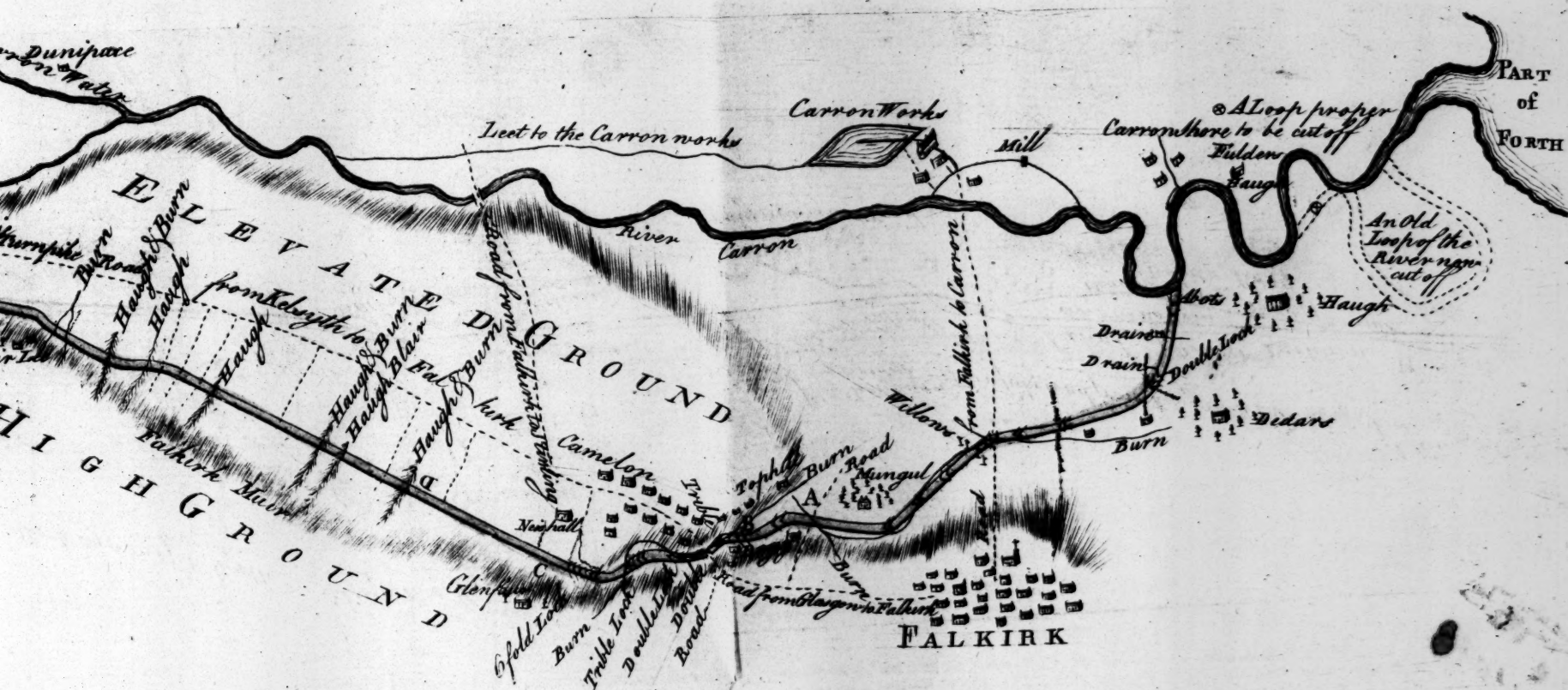
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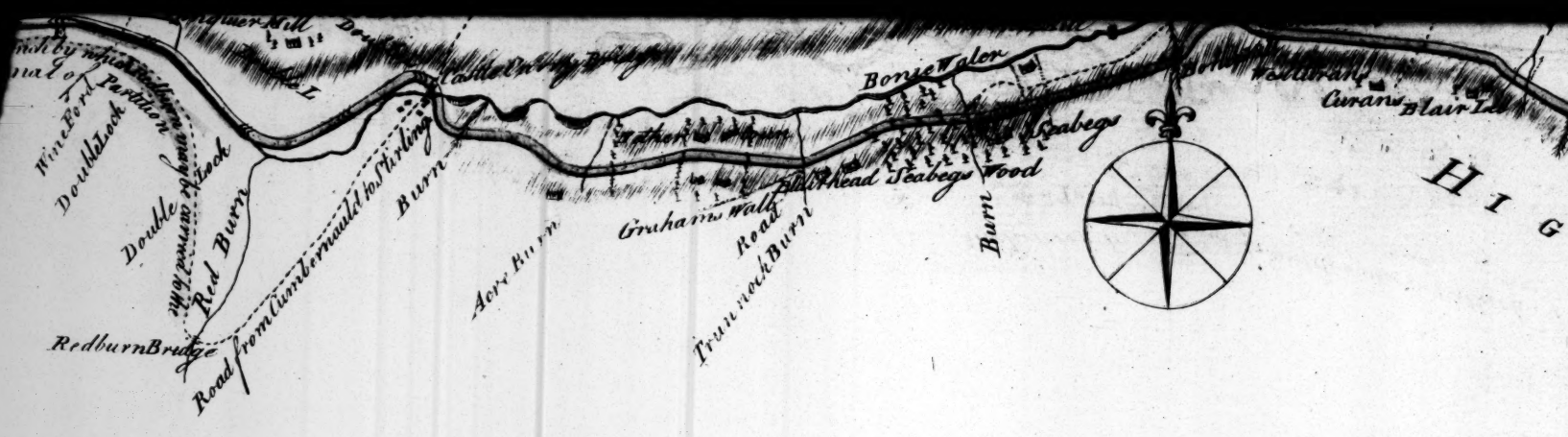
A Scale of English Miles and Furlongs



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